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CONSIDERATIONS ON FORMING OF NONFEROUS METALLIC MATERIALS BY SEMI-SOLID INJECTION MOULDING

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ABSTRACT: This paper presents an overview about the semi-solid metal injection molding of nonferrous metallic materials with applications and advantages. The semi-solid metal injection molding is a foundry-free process that uses a completely enclosed machine for pellet feeding, slurry preparation and injection molding of metals. This new technology is being used by manufacturers of parts in fields as electronics, communications, automotives, consumer and hand-held device. The important advantages of the process are environmental friendliness and saving of machining.

KEYWORDS: thixotropic materials, continuously extrusion, injection molding

1. INTRODUCTION

Semi-solid injection metal molding or thixomolding is a new technology for nonferrous metallic materials processing. If the detection of the thixotropic properties of metallic alloys was made by M.C. Flemings and his team, from the Massachusetts Institute of Technology (MIT), USA, on the beginning of the 70's [3], this new technology was introduced in 1990 in industry.

Thixomolding is a foundry-free process that use an integrated machine completely enclosed for pellet feeding, slurry preparation and injection molding of metals. This is a one step process that, unlike the conventional thixocasting, does not requires pre-prepared billets and their heating and transfer.

Net shape parts that need not machining or heat treatment can be made in minutes after the introduction of feedstock in the machine [5].

2. PROCESS PRESENTATION

The operating principle of a thixomolding machine is similar to that of an injection-molding machine for plastics. The sketch of machine is presented on Fig. 1. Pellets of the aim metal alloy composition are fed into the hopper and then, under an inexpensive argon atmosphere, through a connector into the mouth of the barrel. The solid material is then driven by the rotating screw to the extrusion die. The material is simultaneously conveyed while being electrically heated and converted from solid material into a thixotropic semi-solid state [9]. Then after the material reaches the optimum stage of viscosity, it is propelled through a non-return valve into an accumulation zone and injected, by a linear move of the screw at high speed, into a heated mold.

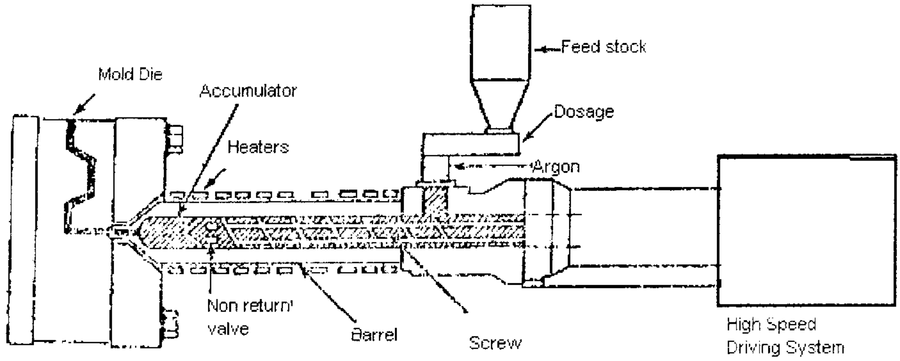

Figure 1. *Semi-solid injection molding machine.*

2.1. Generating of the thixotropic structure

The conventional metal alloys show a dendrite grain structure after casting. Before processing it. in the die, is necessary to achieve a thixotropic structure of the material [10].

Thixotropy is defined as a change of viscosity under the influence of mechanical shear stress due to globular microstructure issued in these conditions. The solid material have to bring it in semi-solid state, to obtain a thixotropic structure, by heating up to a temperature situated under the lichidus curve, while is strong kneaded.

Generating of the thixotropic structure is achieved in the first section of the machine that is a single-screw extruder. The extruder has many possible functions including conveying, heating, mixing, and pumping. Several of these functions may have to be optimized in specific situations.

The performance of the extruder depends strongly on screw design and operating conditions.

The main geometrical variables of the screw are the channel depths, i.e. the radial distance between the barrel inner surface and core of the screw in various sections of the screw.

The main variables of the extruder, which can be controlled during operation, are the speed rotation of the screw, the barrel temperature and the pressure front of the die.

The screw, which rotates in a heated barrel, transports and shears the material into slurry of rounded solid phase embedded in liquid phase. The phase separation, natural in semisolid processing, makes occur a dual-phase microstructure in the parts at solidification. To improve mechanical proprieties, the solid phase can be optimized, in volume and composition, by controlling the barrel temperature. Molding fluidity is enhanced when screw action reduce the size and rounds the solid phase, and when high shear rates, by injection, are employed.

2.2. Forming of thixotropic materials

The final section of machine is composed by a heated mold that can be simple or multi – part.

The thermal management, of the injected stream of slurry in the mold is very important. The temperature drop must be minimized. This is accomplished by multiple injection points, therefore by decreasing of distance, which the slurry needs to traverse in reaching of the mold extreme cavities.
Thus, results a higher fluidity, more laminar flow and more solid phase for reduced porosity, better welding and elimination of cold shuts at knit lines and improvement of surface finish. The engineering of mold must take in account that larger or thinner parts can be molded on the same machine as well as multiple parts in the same shot [5].

3. APPLICATIONS

The parts produced by semi-solid injection molding are currently made from magnesium stock. In the last time, there are researches on zinc and aluminum alloys. In addition, further researches are underway to develop new magnesium alloys with greater creep resistance [10].

The process was first commercially applied in the electronics industry for use in computers, digital camera cases, video camera cases, cell phones, cases for laptop computers, minidisk players and other personal, entertainment and business products, automotive industry and garden tool industry.

4. MAJOR ADVANTAGES OF THE PROCESS

Forming, from nonferrous metallic materials by semi-solid injection molding, is achieved by high-speed injection molding, of semi-solid thixotropic alloys. This technology ensures high quality of net or near net shape parts. The process combines the light weight, high strength, high ductility of magnesium or other alloys, with a safe, simple process, that allows manufacturing of even thin-wall components to tight tolerances.

The net shape parts manufactured by this technology do not require or require very little finishing or puttying. Thus, the need for major secondary machining operations is eliminated. The process permits also molding of multi-dimensional parts in a single mold.

Mechanical properties of the parts are equal or superior to die casting, with significantly reduced porosity. The strength divided by weight ratio is higher compared with engineered plastics. The corrosion resistance is improving also.

It is possible to make parts with thin-wall and with wider range of thickness, from 0.35 to 25 mm, with reduced shrinkage, residual stress and component distortion. Thus, it is ensured a high repeatability of even complex shape of parts.

The parts have better surface finishing and tighter dimensional tolerances. The thixo-molded parts are typically produced with linear tolerances of about ± 0.001mm [5].

The process is environmentally friendly. No ozone depleting gases are used, so there is no concern about the impact of SF6. There are no landfill concerns, since there is no solid waste residue. No sludge or dross is generated. Additionally, the process is worker friendly, since there is no external foundry involved. Therefore, workers are not exposed to molten metals. The entire process takes place in a closed machine, which can be monitored and controlled by one person. Operating temperatures are about 100°C, under than typical die cast operation temperatures [11]. Other advantages include excellent recyclability and economy of manufacture. The process ensures simplifying of production of more complex parts resulting in net savings.

Forming from nonferrous metallic materials, by semi-solid injection molding, lets people be more productive in ways that have real impact on daily operations. The process features simple automated control systems similar to plastic injection molding, start up and shut down can be completed in 30 minutes rather than the hours required for conventional die casting, longer die life means more shots without erosion, consistent repeatable processes mean less variation and less waste, net shape forming can virtually eliminate machining or puttying [11].

5. CONCLUSIONS

The numerous applications of this process on making parts for edge fields of economy as well as major technical, economical advantages and environment friendness [11], recommend to continue the researches concerning forming of nonferrous metallic materials by semi-solid injection molding.

REFERENCES

1. K. Young, P. Eisen, Proceedings of 6th International Conference, Turin, (2000), 97.
2. M.P. Kenney, J.A. Courtoiss, Metals Handbook, 9th edition, Casting, **15** (1989), 231-236.
3. J. Collot, Fonderie-Fondeur d'aujourd'hui, **129** (1993), 35-45.
4. W.L. Winterbottom, Proceedings of 6th International Conference, Turin, (2000), 73.
5. D. Waluka, S. LeBeau, N. Prewitt, R. Decker, Proc. 6th Int. Conf., Turin, (2000), 109.
6. H. Peng, H. Wen-Min, Proceedings of 6th International Conference, Turin, (2000), 313.
7. A. Georgescu, St. Craciun, A. Raducanu, Prelucrari la cald, **1** (1995), 17.
8. A. Neag, Conferinta nationala de metalurgie si stiinta materialelor, Bucuresti, (2001), 192.
9. A.Neag, T.Canta, A doua Conferinta nationala "Profesorul Dorin Pavel-fondatorul hidroenergeticii romanesti", Sebes, **1** (2002), 287.
10. P.R. Sahm, M. Fehlbier, O. Klassen, J. Aguilar, Proc. Int. Conf. BRAMAT, Brasov, (2001), 177.
11. *** Thixomat WEB site.